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UNITED STATES PATENT APPLICATION

Title:

**MOTORCYCLE FORK BOTTOM HAVING
DIFFERENT LONGITUDINAL STIFFNESS AND
ADJUSTABLE SIDEWAYS STIFFNESS**

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1 **MOTORCYCLE FORK BOTTOM HAVING**
2 **DIFFERENT LONGITUDINAL STIFFNESS AND**
3 **ADJUSTABLE LATERAL STIFFNESS**

4 **Background of the Invention**

5 Technical Field of the Invention

6 This invention relates generally to suspension components for two-wheeled vehicles, and
7 more specifically to front fork components.

8 Background Art

9 The vast majority of motorcycles are equipped with a sliding-tube or telescopic front
10 suspension, consisting of a pair of forks coupled to the front axle and to the steering head of the
11 motorcycle's frame. The forks are either of the "right-side-up" or sliding-female configuration,
12 or the "upside-down" or sliding-male configuration. In either case, a cylindrical tube or piston
13 slides axially within a generally cylindrical cylinder. As a motorcycle rider applies the front
14 brake, the front forks are subjected to significant flexing force and torque in the direction of
15 travel, as the rearward force on the front tire's contact patch presses rearward on the bottom of
16 the forks at the axle, while the inertia of the motorcycle's mass presses forward on the top of the
17 forks at the triple-clamps. Manufacturers battle this flex by using larger-diameter and thus stiffer
18 fork tubes.

19 Fork flex, especially under braking, is a significant contributor to the stiction which is
20 known to dramatically reduce the effectiveness and perceived quality of a motorcycle's front
21 suspension. The manufacturer may battle this stiction by making even greater increases in the
22 diameter and stiffness of the fork tubes.

23 These engineering changes have an unfortunate side effect, which is exposed by the fact
24 that motorcycles lean to the inside when cornering. In general, the faster a corner is taken, the
25 farther over the motorcycle must lean. While leaned over, the axis of the fork suspension is not
26 perpendicular to the ground, and yet the front tire's contact patch (which is at the center of the
27 tire when riding straight, but is significantly off to the side of the tire when the bike is leaned
28 over) remains parallel to the ground. Then, when the front tire encounters a bump in the road, the
29 bump forces the tire in the vertical direction, perpendicular to the ground. But, because the forks

1 are not oriented in that direction, the effect is that the force of the bump is applied to the forks
2 somewhat laterally (in other words, radially or sideways), rather than axially with respect to the
3 sliding ability of the fork tubes.

4 The forks' stiffness, which the engineer gave the fork tubes to counteract flex under
5 braking, is now doing exactly the wrong thing with respect to the force of the bump – it is
6 fighting the bump, rather than supplely allowing the front tire to track the road surface and
7 remain in contact with the ground. Riders experience this as one form of front end chatter,
8 especially when traversing an extended section of bumpy or rippled racetrack corner. The result
9 is often a front end push which may end in a crash.

10 What is needed, then is an improved front fork which has suitably low lateral stiffness to
11 better enable the front tire to track ground irregularities while leaned over cornering, without
12 compromising its excellent longitudinal stiffness to resist flexing under hard braking. What is
13 further desirable is such a fork which has adjustable lateral stiffness.

14 **Brief Description of the Drawings**

15 The invention will be understood more fully from the detailed description given below
16 and from the accompanying drawings of embodiments of the invention which, however, should
17 not be taken to limit the invention to the specific embodiments described, but are for explanation
18 and understanding only.

19 FIG. 1 shows a motorcycle front end equipped with one embodiment of a fork according
20 to this invention.

21 FIG. 2 shows one embodiment of a fork according to this invention.

22 FIG. 3 shows an exploded view of the components of one embodiment of a motorcycle
23 front end according to this invention.

24 FIG. 4 shows a more detailed exploded view of some of the components of one
25 embodiment of a fork bottom according to this invention.

26 FIG. 5 shows a different angle view of the fork bottom, particularly pointing out the
27 attachment points for the flex control mechanism.

28 FIG. 6 shows another embodiment of a fork bottom which has different lateral and
29 longitudinal stiffness.

FIG. 7 shows a motorcycle equipped with one embodiment of a flexible fork bottom of this invention.

Detailed Description

FIG. 1 illustrates one embodiment of a motorcycle front end 10, viewed generally from the front. The front end includes a tire 12 mounted on a wheel 14 and equipped with brake rotors 16 and brake calipers 18. A fork bottom 20 includes a fork bottom body coupled to the axle 22 and to a pair of male lower fork tubes 24 which slide in a pair of female upper fork tubes 26. The longitudinal (in the direction of travel) stiffness of the fork bottom is different than the lateral (side-to-side) stiffness of the fork bottom. In one embodiment, the longitudinal stiffness is greater than the lateral stiffness. In some embodiments, the lateral stiffness of the fork bottom is adjustable, as explained below.

A lower triple clamp 28 and an upper triple clamp 30 are coupled to the upper fork tubes and couple them to a steering stem assembly (not visible) which rotates within a steering tube 32 which is part of, or coupled to, the frame (not shown) of the motorcycle.

The front end 10 thus pivots or rotates about a steering axis which is coaxial with the steering tube 32. This invention differs from the prior art in that at least one of the spring (suspension) and/or shock (damping) components is coaxially disposed within the steering tube. In one embodiment, a monoshock 34 provides both spring support and damping for the front end, while in other embodiments, a more conventional cartridge system (not shown) could be employed within the fork tubes. The bottom end of the monoshock is coupled to a fork buttress 36. The fork buttress may be coupled to the lower fork tubes or to the fork bottoms. In one embodiment, the fork buttress comprises two halves, each of which is integrally formed with a respective fork bottom, as shown.

FIG. 2 illustrates one embodiment of a fork 40 according to this invention. The fork includes an upper fork tube 26, a lower fork tube 24, and a fork bottom 20. The fork bottom includes a sturdy upper end 42 adapted for receiving and retaining the lower fork tube by any suitable means such as pinch bolts (not shown), threads (not shown), or the like. In one embodiment, the fork's half buttress 36 is integrally formed with the sturdy upper end of the fork bottom. The fork bottom further includes a lower end 44 adapted for receiving and retaining the axle assembly (not shown) and the brake caliper (not shown) by any suitable means. The upper

1 fork tube includes an upper end 46 adapted for being secured to the upper triple clamp (not
2 shown) by any suitable means, such as threads (not shown) or pinch bolts (not shown). The
3 upper fork tube includes a lower end 48 adapted for providing a good sliding fit with the lower
4 fork tube.

5 In some embodiments, especially those in which both the spring and shock components
6 are located coaxially within the steering tube, the forks can be much simplified versus the prior
7 art. For example, the telescoping fork tubes do not need to be made to have a fluid-tight seal, as
8 there is no need for them to retain the oil which would be used in a damping system. In fact, in
9 some embodiments, it will be found desirable to ventilate the upper fork tube, the lower fork
10 tube, and/or the fork bottom, to eliminate any pressurization caused by the pumping action of the
11 forks as they extend and compress.

12 FIG. 3 illustrates the suspension components 50 of the motorcycle front end, viewed
13 generally from the front and shown in an exploded view. For ease of illustration, only a single
14 fork will be described. The upper fork tube 26 threads into the upper triple clamp 30. A fork cap
15 52 seals the open end of the fork tube to prevent gross contamination of the sliding components,
16 but is not necessarily an airtight seal. A stationary fork bushing 54 and a seal 56 fit within the
17 lower end 48 of the upper fork tube, and are held in place by a snap wire 58. A sliding fork
18 bushing 60 mates with the upper end 62 of the lower fork tube. The stationary and sliding fork
19 bushings provide a low-stiction but tight-tolerance sliding fit of the lower fork tube within the
20 upper fork tube. In practice, the components may need to be assembled in a slightly different
21 manner than suggested by this exploded view, as the bushings are not generally able to slide past
22 each other, and their interference is part of what keeps the telescopic forks from telescoping
23 completely to disassembly.

24 A shock tube 66 rotates within the steering tube 32 on an upper bearing 68 and a lower
25 bearing 70. A jam nut 72 and washer 74 secure the upper bearing onto the shock tube. A top bolt
26 76 threads into the shock tube and secures it to the upper triple clamp.

27 The lower end 78 of the lower fork tube threads or otherwise couples to a hole 80 in the
28 upper end 42 of the fork bottom 20. The upper end of the monoshock 34 fits up into and engages
29 the shock tube, while the lower end of the monoshock engages the fork buttress 36 at the upper
30 end 42 of the fork bottom.

1 The lateral stiffness of the fork bottom is controlled by a tension cable 82. The lower end
2 84 of the tension cable engages the fork bottom, while the upper end 86 of the tension cable is
3 engaged and tensioned by a tension adjuster 88. The tension adjuster and a washer 90 engage a
4 tension adjuster block 92 which fits into a hole 94 in the upper end of the fork bottom. A detent
5 ball 96 retains the tension adjuster within the tension adjuster block and, in some embodiments,
6 provides “clicker” adjustment feedback as is commonly present in other motorcycle suspension
7 adjustments such as compression and rebound damping. For aesthetics and aerodynamics, a fork
8 bottom inner cover 98 may be coupled to the inward portion of the fork bottom, covering the
9 tension cable and other components. In some embodiments, the tension cable may be a tension
10 rod. In some embodiments, the tension rod may apply tension or pull, while in other
11 embodiments it may provide extension or push.

12 FIG. 4 illustrates further details of one embodiment of the adjustable flex fork bottom
13 assembly 100. The left fork bottom 20 is shown, as viewed from the front and right, or generally
14 where the front of the tire would be. The side wall 102 of the fork bottom provides stiffness in
15 the longitudinal direction, the direction of travel and braking, while the fact that the fork bottom
16 is not a complete cylinder gives it a measure of lateral flex, from side to side.

17 A gusset 104 near the middle of the fork bottom provides a fulcrum over which the
18 tension cable 82 is stretched, and may be provided with one or more grooves 106 or bearings or
19 other means for holding the tension cable in a desired position. The lower end 84 of the tension
20 cable is provided with a ball or other means for coupling to the lower end of the fork bottom. The
21 upper end of the tension cable is provided with a threaded rod 86 which engages threads on the
22 tension adjuster 88. The tension adjuster may be provided with a hexagonal socket 108 by which
23 a mechanic can set the flex by tightening or loosening the tension cable, and thus the lateral
24 pressure on the fulcrum 104, thereby changing the amount of lateral flex of the fork bottom. In
25 other embodiments, other adjustment mechanisms may be employed, such as a cammed lever.

26 As the tension on the tension cable is increased, the fork bottom is placed under increased
27 lateral tension as the tension cable presses down harder and harder on the fulcrum. This tends to
28 make the fork bottom less flexible in the side-to-side dimension, while having little effect on its
29 stiffness in the longitudinal direction. Thus, the invention enables the rider to set up his front
30 suspension to be more or less compliant in lateral flex, to tune the suspension for the mid-corner

1 bumpiness or smoothness of a particular road or racetrack, without compromising longitudinal
2 stiffness which provides good control under heavy braking and which helps eliminate stiction in
3 the telescopic fork tubes. In some cases, the rider may even choose to adjust one fork's sideways
4 flex differently than the other's.

5 The skilled suspension engineer will be able to select materials, thicknesses, and
6 geometries to provide the desired longitudinal and lateral stiffnesses for his application at hand.
7 For example, in one embodiment, the entire fork bottom is constructed as a monolithic metal
8 structure, such as of cast aluminum. In another embodiment, the central portion of the fork
9 bottom may be fashioned of carbon fiber, while the upper and lower ends may be fashioned of
10 titanium.

11 FIG. 5 illustrates the left fork bottom 20 in further detail, viewed from the front and
12 below, to better demonstrate the mounting of the tension cable (not shown). The upper end of the
13 tension cable is fed through a hole 110 in the lower end of the fork bottom and pulled through
14 until the ball engages the hole 110. The cable is routed through the groove 106 on the fulcrum
15 104 and through a hole 112 in the upper end of the fork bottom, then the tension adjuster (not
16 shown) is engaged with the tension cable to place it under tension and retain it.

17 In other embodiments, alternative mechanisms could be used instead of the tension cable.
18 For example, a pair of threaded rods could each engage the fulcrum and a respective end of the
19 fork bottom, and the rods could be used to place the fork bottom under tension or even under
20 elongating pressure, and the rods could operate independently in some modes. Or, the tension
21 adjustment could be made at the fulcrum, rather than at the end of the tension cable, such as via a
22 jack screw. In another embodiment, the adjustable tension cable could be replaced by a set of
23 alternative vertical inserts placed inside the fork bottom to provide various amounts of
24 end-to-end pressure or tension. Such inserts would advantageously be placed generally
25 perpendicular to the side wall and fulcrum shown in these drawings.

26 FIG. 6 illustrates another embodiment of a fork bottom 120 which has a different
27 stiffness in the longitudinal direction than in the lateral direction. Shown is a right fork bottom,
28 seen from the front and left. The fork bottom includes an upper end 122 adapted with a hole 124
29 for receiving the lower fork tube (not shown), and a lower end 126 adapted with a hole 128 for
30 receiving the axle (not shown). A slot 130 and a pinch bolt hole 132 are provided for retaining

1 the axle by a pinch bolt (not shown). The middle portion 134 of the fork bottom includes a side
2 wall 136 which provides good longitudinal stiffness. A series of slits 138 soften the central
3 portion of the fork bottom, giving it more flexibility in the lateral direction. The slits may be
4 provided with holes 140 at their terminal ends, to prevent the slits from tearing or spreading
5 further through the material of the fork bottom. As the fork bottom flexes toward the side such
6 that the slits compress, at the point at which the sides of the slits meet, the fork bottom will
7 become more rigid. In some embodiments, the slits may be made of different dimensions (e.g.
8 vertical height in the orientation shown), such that they do not all pinch closed at the same
9 amount of lateral flex, for a more “progressive” and less abrupt increase in the lateral stiffness of
10 the fork bottom.

11 FIG. 7 illustrates a motorcycle 150 adapted with the front end 10 having the forks 40 of
12 the present invention, including upper fork tubes 26 and lower fork tubes 24, and including fork
13 bottoms 20 having different longitudinal stiffness and lateral stiffness, and having adjustable
14 lateral stiffness.

15 Conclusion

16 While the invention has been described with reference to its use in a motorcycle, the
17 invention is not limited to motorcycles, but can be used in bicycles, automobiles, and other
18 vehicles. And while the invention has been shown as using an “upside-down” fork, it may
19 alternatively be used with a “right-side-up” fork. Some components have been illustrated as
20 being of monolithic construction, while other components have been illustrated as being separate
21 components coupled together. The skilled reader will readily appreciate that the designer may
22 elect, within the scope of this invention, to split some components into separate sub-components,
23 or to combine various components into a monolithic whole. For example, the lower fork tube and
24 the fork bottom could be formed as one integral component. The fork bottom has been shown
25 having a length such that it extends above the top of the front tire, but the invention is not thus
26 limited; rather, any suitable length fork bottom may be used, so long as it has meaningfully
27 different stiffness in the longitudinal and lateral directions (in contrast to the small mounting
28 structures, typically machined from billet, which are found on the bottom of conventional
29 upside-down forks).

1 The reader will further appreciate that the invention may be practiced in a suspension
2 having only a single fork, and that the “triple clamps” will not in that case have means for
3 coupling a third tube, but only the steering tube and the upper fork tube. The reader will further
4 appreciate that, in some applications, it may actually be desirable to make the lateral stiffness
5 higher than the longitudinal stiffness. The reader will further appreciate that the tension cable
6 may be used to adjust the longitudinal stiffness, rather than the lateral stiffness.

7 When one component is said to be “adjacent” another component, it should not be
8 interpreted to mean that there is absolutely nothing between the two components, only that they
9 are in the order indicated. The various features illustrated in the figures may be combined in
10 many ways, and should not be interpreted as though limited to the specific embodiments in
11 which they were explained and shown. Those skilled in the art having the benefit of this
12 disclosure will appreciate that many other variations from the foregoing description and
13 drawings may be made within the scope of the present invention. Indeed, the invention is not
14 limited to the details described above. Rather, it is the following claims including any
15 amendments thereto that define the scope of the invention.